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Asbestos-Cement Materials Used in Water Supply An Assessment of Current Information on the Occurrence and Question of Health Risk of Asbestos Fibers in Drinking Water Supplies

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Asbestos-Cement Materials Used in Water Supply

An assessment of current information on the occurrence and question of health risk of asbestos fibers in drinking water supplies.

by J. R. Millette, M. F. Pansing and R. L. Boone

Asbestos is a general name for a group of fibrous silicate minerals. When mixed with cement in concentrations between 10 and 25 percent, the fibers help bind and reinforce the finished product. Chrysotile, a serpentine mineral, is the most common form of asbestos used in cement, although crocidoite and amosite, amphibole minerals, are also used.

It is clearly evident that water can corrode asbestos-cement materials and release fibers into drinking water. Asbestos-cement roofing tiles have been used in some areas for many years to collect water for home drinking-water cisterns. After a number of years of exposure to the weather, the surface of the tile is deteriorated and fibers are released into the water. Fiber concentrations in the drinking water and in the rainwater coming directly off the roof were in the hundreds of millions of fibers per liter (**Table 1**).

Some asbestos-cement building materials have been used in the construction of water-supply facilities. In one case, an asbestos-cement parapet wall was erected around a reservoir to keep animals out. The forming process caused the side toward the reservoir to be quite rough. A Scanning Electron Microscope (SEM) study of the surface showed a high number of exposed fibers which can be eroded into the water. After a number of water analyses, it was concluded that the erosion of fibers from the parapet wall caused intermittent high concentrations of asbestos fibers in the reservoir, which serves as a drinking-water source.

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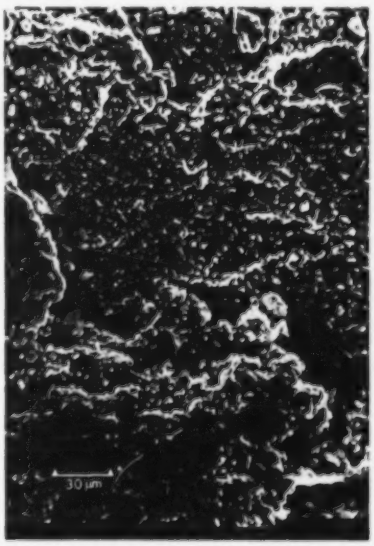

Figure 1. (left) Appearance of inside of new A/C pipe under Scanning Electron Microscope (SEM).

Figure 2. (right) Inside of A/C pipe, after exposure to corrosive water, as it appears under Scanning Electron Microscope.

Asbestos-cement (A/C) pipe is used to deliver drinking water in a number of utilities throughout the United States. When new, the inside surface is fairly smooth; its appearance under the SEM is shown in **Figure 1.** When subjected to corrosive water, however, the inside surface of the pipe can be corroded and fibers may be released into the drinking water. The inner surface of corroded A/C pipe is shown in **Figure 2** at the same magnification as **Figure 1.**

Concentrations of asbestos fibers in some asbestos-cement pipe systems have been found to be high (**Table 1**). In other asbestos-cement pipe systems no fibers have been detected in the water. One example of A/C pipe under attack is the instance of a 12-yr. old, 4-in. asbestos-cement pipe system in Wisconsin. The well water entering the distribution lines would be considered by several indices to be corrosive. Although no work had been done on the pipe in the pevious eight years, wads of material were found in home faucet screen strainers. An investigation by scanning electron microscopy showed the wads to be composed of fibrous asbestos.

One water sample taken from a fire hydrant after one full minute of flushing was analyzed by transmission electron microscope methods and showed a fiber concentration of about 10 billion fibers per liter. Fiber concentrations in the household taps were about 5 and 7

continued on page 51

A/C Materials

continued from page 48

million fibers per liter. There are other examples of corrosive water attacking A/C pipe and also examples of systems with no apparent attack.[1]

How widespread is corrosion of A/C pipe and how many people may be affected?

Although it has been estimated that there are about 200,000 miles of A/C pipe in use in the U.S.,[2] it is important to know how much of this pipe receives potentially corrosive water. One approach to determining whether a water is corrosive or not was proposed by the American Water Works Association Standard Committee on Asbestos-Cement Pipe.[3] An aggressiveness index (A.I.) was derived from the Langelier Calcium Carbonate Saturation Index.

According to this index the aggressiveness of water transported through a pipe, within the temperature range of 40–80 degrees F, is determined by the formula:

$$A.I. = pH + \text{Log}_{10}(A \times H)$$

where
pH is in standard pH units
A is total alkalinity in mg/L as $CaCO_3$
H is calcium hardness in mg/L as $CaCO_3$

Higher values of this aggressiveness index are less corrosive than lower values. Water with an A.I. less than 10 corresponds to a Langelier Index less than -2.0 and is considered very aggressive to all types of pipe. An A.I. greater than 12 corresponds to a Langelier Index of 0.0 or greater and is considered essentially nonaggressive.

A survey of representative water utilities suggests that 16.5 percent of the United States water utilities distribute highly aggressive waters[4] (**Table 2**).

Table 2
Representative Average U.S. Utility Aggressiveness Indices[4]

Highly Aggressive (A.I.<10) = 16.5 percent
Moderately Aggressive (10<A.I. 12) = 52 percent
Non-aggressive (A.I.<12) = 31.5 percent

Sixteen and one-half percent of the 200,000 miles of A/C pipe provides a rough estimate of 33,000 miles of A/C pipe exposed to highly aggressive water. Analysis of a 1976 American Water Works Survey of Operating Data for Water Utilities suggests that an average of 300 persons are served for each mile of pipe.[5] Using these data one can estimate that about 10 million people might be exposed to corrosive water flowing through asbestos-cement pipe. An additional 30 million might be affected to a lesser extent if the utilities distributing moderately aggressive water are included (**Table 2**).

Table 1
Comparison of Asbestos Concentrations Found in Some Drinking Water Systems

	Range of Asbestos Concentration Millions of Fiber/Liter
Asbestos-cement tile roof	
Cisterns, St. Croix, VI	15 — 500
Cisterns, St. Thomas, VI	20 — 30
Cistern, Oxford, OH	96
Asbestos-cement pipe**	
Bishopville, SC	0.4 — 500
Kentucky Dam Village, KY*	— 45
Lakeland, FL*	0.2 — 17
Lockhart, TX	BDL‡
New Milford, CT	BDL
Northridge, OH	BDL
Paint, PA	4 — 19
Pensacola, FL*	0.05 — 32
Natural erosion	
San Francisco, CA	BDL — 130
Seattle, WA	BDL — 25
Everett, WA*	35 — 230

**Corrective studies reported underway.*
‡Below detectable limits of asbestos analysis. ***Some samples taken at fire hydrants.*

Other factors have not been accounted for in these calculations. For instance, A/C pipes are often used for the primary main, and one section at the beginning of the line would distribute water to the whole town. In the 82 towns that use A/C pipe in Connecticut there are several cases of this type. Instead of the national average of 300 persons served by mile of pipe, in Connecticut each mile of A/C pipe serves more than 1,200 people. This statistic suggests that the total population affected by aggressive water flowing through A/C pipes may be greater than 10 million.

On the other hand, 45 out of 46 towns in Connecticut that were classified as having highly aggressive water had no evidence of corrosion in the system, no high-fiber counts or reports of deteriorated pipe that had been unearthed. This observation suggests that while a number of people are served by asbestos-cement lines receiving water considered aggressive by one index, some people may not be affected because the pipe surface is being protected in some manner. Iron, zinc, and manganese are known to be able to coat the inside of A/C pipe under some conditions and thereby prevent fiber release.[1]

A number of asbestos analyses have been performed in utilities throughout the country and are summarized in **Table 3**. Some asbestos-cement pipe systems in Pennsylvania, Florida, Wisconsin, Arizona, South Carolina, and Kentucky have been identified as under attack by corrosive water. Cisterns using asbestos roofing tiles have been found in Ohio, and the Virgin Islands. Based on the previously described estimates, more than 10 million people may be exposed to concentration of asbestos fibers in the range of millions of fibers per liter resulting from the corrosion of asbestos-cement materials.

Potential health hazard? Asbestos is a human carcinogen. Studies have shown that persons exposed to airborne asbestos in the workplace have several times the chance of getting cancer as those that have not worked with asbestos. Concern from ingested asbestos stems primarily from the number of studies of occupational workers which have shown excess gastrointestinal cancer. **Table 4** lists several of these studies and it is clear that the observed gastrointestinal cancers exceeded the expected number of G.I. cancers for the groups of workers studied.[6–14] Although the workers' exposures to asbestos were to airborne material, it appears plausible that many of the fibers breathed and deposited were cleared and swallowed.[15]

Table 3
Distribution of Reported Asbestos Concentrations in Drinking Water from 426 Supplies in 48 States, Puerto Rico, Virgin Islands and the District of Columbia

Highest Asbestos Concentrations Reported (millions of fibers/liter)	Number of Supplies	Percentage
Below detectable limits	121	28.4
Less than one	221	51.9
One to ten	39	9.2
Greater than ten	45	10.6
Total	426	100.1

continued on page 50

continued from page 51

In 1974, there were statements that fibers did not cross the gut into the body,[16] but more current studies suggest otherwise. Asbestos fibers up to 35 microns long were found in the kidney and other organs of a newborn baboon that was bottle fed asbestos in formula.[17] This suggests that fibers of all sizes can penetrate the gut. Amphibole fibers were found in the urine and tissues of persons who had ingested drinking water containing the fibers in Duluth, Minnesota.[18] Residents on other unpolluted sources did not have amphibole fibers in their urine. A report by a group at the Mayo Clinic also substantiates the migration of asbestos fibers through animal tissue.[19] These data, along with evidence of other materials, clay fibers, starch granules, and latex spheres penetrating the gut wall leaves little doubt that ingested asbestos fibers can get into the body.

Although asbestos and other fibrous materials injected or implanted into animals have resulted in the production of malignant neoplasms, animal studies of ingested asbestos have not thus far shown any truly conclusive health risk of asbestos in drinking water. The Safe Drinking Water Committee of the National Academy of Sciences reviewed the animal toxicology results available through 1976.[20] The committee reported that four studies did not show evidence of increased cancer incidence by asbestos ingestion. One study showed the development of 12 malignant tumors in a group of 50 rats that were fed asbestos-containing filter material. The NAS group felt that each study was deficient in some way and that the matter was unresolved. The results of two limited asbestos feeding studies were reported in 1977. Although some cancers were reported, the data are not considered conclusive because of the limited number of animals.[21]

A large-scale asbestos feeding study is currently underway with rats and hamsters, but final results are not available yet. The results of this large-scale feeding study will provide important data. However, as the NAS cautioned: negative results may be interpreted as indicating either the absence of an effect of ingested asbestos or as further proof that the animal model was not valid to start with. If certain animal species do not get cancer, the excess gastrointestinal cancer among the asbestos insulation workers must still be explained.

As shown in **Table 2**, people in a number of towns have been drinking water containing asbestos fibers. In Duluth, were amphibole fibers were contributed to the water supply as a result of an industrial discharge, several studies have not shown a relationship between increases in cancer risk and drinking water containing amphibole fibers.[22] Occupational studies have shown a rather long time interval between exposure to asbestos and onset of cancer (latency periods of 20–30 years have been reported). The studies in Duluth after only 15 years exposure may not have shown anything because of this time factor. Studies are in progress to continue monitoring the cancer rates there.

In Connecticut, no association between the use of asbestos-cement pipe and elevated cancer risk could be found.[23] Analysis of the water in all the towns, however, showed that people were not exposed to very great numbers of fibers as compared to other areas of the country. Studies are underway in Florida where an asbestos-cement pipe system is known to have had high fiber counts in the past and in the Pacific Northwest where there is a natural source of asbestos eroding into a reservoir. There are no conclusive results in either study as yet. One study of residents around San Francisco did show a statistically significant association between asbestos levels in drinking water and male stomach and lung and female peritoneal, gall bladder, and esophageal cancers.[24] A study in a natural asbestos area of Canada concluded no excess cancer risk could be attributed to the water containing high levels of asbestos.[25] There were, however, statistically significant increased rates for male stomach and lung and female pancreatic cancer.

Table 4
Gastrointestinal Cancer in Occupationally Exposed Asbestos Workers[6-14]

References	Observed Deaths/ Expected Deaths
Insulation workers	
Elmes and Simpson (1971)	3.0
Kleinfeld, et al. (1967)	3.9
Selikoff, et al. (1976)	3.15
Selikoff, et al. (1979)	1.68
Factory workers	
Henderson and Enterline (1979)	1.4
Newhouse and Berry (1979)	
Severe exposure	2.31
Seidman, et al. (1979)	1.49
Mining and milling	
Kogan, et al. (1972)	
Male miners	4.30
Female miners	3.60
Female millers	19.90
McDonald and Liddell (1979)	
Heavy exposure	2.89

In 1979, in response to a lawsuit, the Environmental Protection Agency was required to develop water-quality criteria for 65 pollutants including asbestos. These criteria relate to toxic discharges to surface waters and consider human exposure from both drinking water and fish consumption. Data on excess gastrointestinal cancer from several occupational studies were used with exposure data and conversion factors to estimate that the ingestion of 300,000 asbestos fibers per liter of water over a 70 yr. lifetime would result in one additional death per 100,000 people. This human risk value as part of the criteria document was published in the Federal Register on October 1, 1979, for public comment. The value was unchanged in the final document published in the Federal Register in Nov., 1980. Because of the number of assumptions made, this risk estimate is not considered a drinking-water standard.

Conclusions. More than 40 million people may be exposed to asbestos fibers in their drinking water as a result of the corrosion of asbestos-cement products. Although the available data are not considered to be conclusive enough to support a drinking-water standard for asbestos, it seems prudent to take steps to prevent the release of asbestos fibers from asbestos-cement materials in contact with the water supply. Asbestos-cement materials should not be used in the construction of water supplies or the distribution of drinking water where those materials may be attacked by corrosive water. In areas where A/C pipe is presently under attack by corrosive water, investigations should be made into the promising techniques for treating the water and coating the pipe to prevent further release of fibers.

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continued on page 97

continued from page 60

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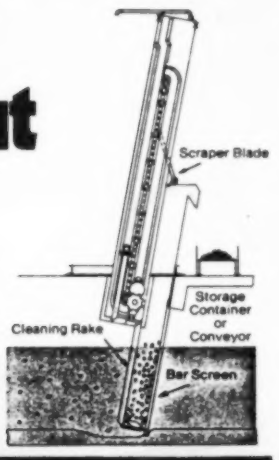

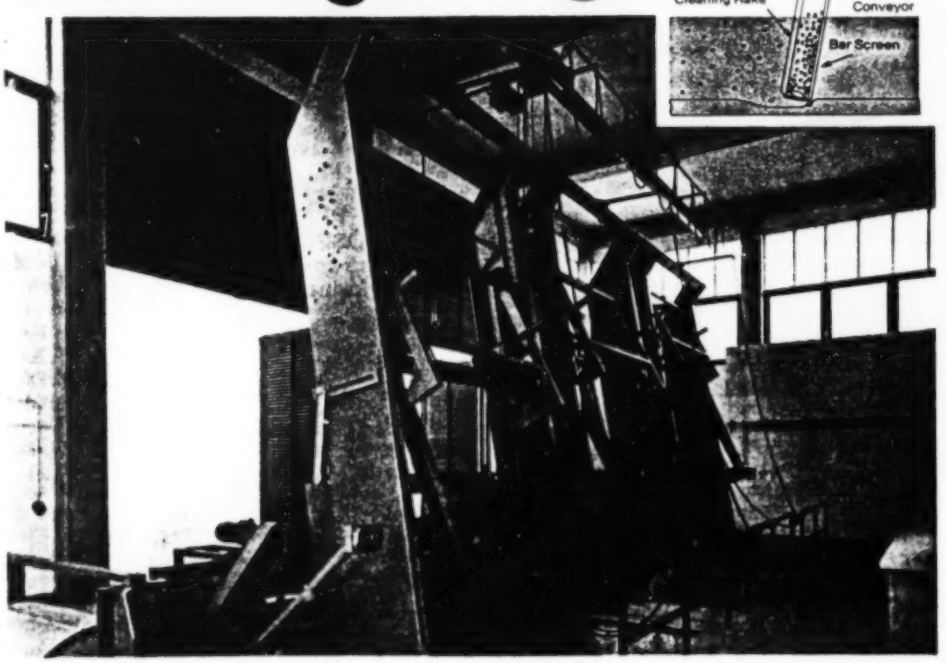

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